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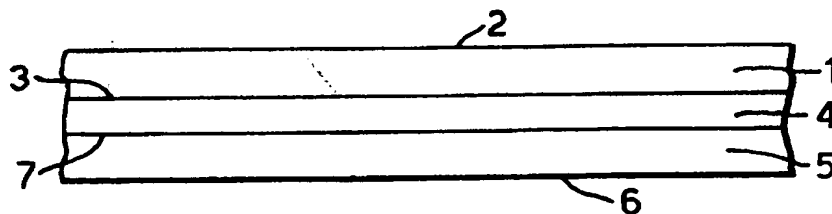
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(54) Title: ELASTIC THIN-WALLED ARTICLES

(57) Abstract

The transmission of fluid and/or of  
disease through thin-walled elastomeric ar-  
ticles such as medical and surgical gloves  
is reduced or prevented by providing a  
layer (4) of a xerogel containing a protec-  
tive agent, in the article. The xerogel layer  
(4) can be disposed between two elastomer  
layers (1, 5).



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### ELASTIC THIN-WALLED ARTICLES

This invention relates to elastic thin-walled articles, particularly but not exclusively surgical and medical gloves and condoms, and to a method of making them.

Elastic thin-walled articles such as gloves and condoms serve to protect the user against inter alia the transmission of disease. There have been a number of proposals designed to improve the protection afforded by such articles. U.S. patent no. 5165953 discloses providing a chemical barrier in a latex material by coating a former with latex, applying a coating of biocide thereover, and then applying a second coating of latex. The biocide is thus sandwiched between the two layers of latex and is released upon rupture or piercing of the latex. In addition, the biocide will reduce or prevent transmission of microbes through the latex via any pores therein.

In U.S. patent no. 5483697, there is a similar approach but here a sealing solution is provided between two latex laminae, and this solution serves not only to contain a biocide (or other protective material) but also to seal up any ruptures or holes which are formed in use of the article. One of many possible sealing solutions comprises a hydrogel which is swollen with an aqueous solution of biocide or other protective agent. U.S. patent no. 5549924 also describes the

use of a double-layer membrane with biocide or another material in the reservoir formed between the two layers. One suitable material is a hydrogel which functions by absorbing the biocide to hold the membrane layers apart.

Whilst these proposals are to some extent satisfactory, there are disadvantages in having a swollen soft hydrogel (or other liquid containing material) between the two latex layers. Not only can this be difficult to manufacture, but it also can give rise to difficulties in controlling thicknesses etc. and there can be problems in achieving a satisfactory "feel" especially in surgeons' gloves.

We have now found a way of overcoming these problems. In particular, we have found that very satisfactory protective biocidal effects can be achieved by providing the biocide (or other agent) in a xerogel, i.e. in a hydrogel which is practically completely dry and unswollen. In this way, the various problems associated with the prior known use of water-containing hydrogels are avoided without loss of the biocide release requirement which is important to the protective functioning of the article.

It is surprising that a dry hydrogel layer, i.e. a xerogel, will function as well as (and in many respects better than) the prior taught wet swollen layers since it might be expected that a dry layer would not provide such good sealing or produce the necessary supply of active biocide. However, the xerogel layers of the invention not only are very effective but also give a number of other advantages.

In one aspect, the invention provides a thin-walled elastic article which comprises two layers of elastomer with a layer of xerogel containing a protective agent sandwiched therebetween.

The invention also provides a method of making such an article which comprises providing, between two layers of elastomer, a layer of xerogel containing a protective agent.

We have further found that it is also possible to achieve the aims of the invention by making a single layer elastomer article having a xerogel layer

(containing the protective agent) over at least part of one surface, and then using such an article with a second article (which need not have any xerogel layer), the second article (in use) lying over the xerogel layer of the first article.

Thus, the invention also provides a thin-walled elastic article which comprises a layer of elastomer with a layer of a xerogel containing a protective agent over at least part of a surface of the elastomer layer.

The invention further provides such an article in association with a second thin walled elastic article to be worn or otherwise used over or under the first article with the xerogel layer sandwiched between the elastomer layer and the second article.

This arrangement is particularly, but not exclusively, useful for gloves, and the invention thus provides a thin-walled elastic article comprising a layer of elastomer with a layer of a xerogel containing a protective agent over at least part of a surface of the elastomer layer, in the form of a glove, in association with a second article which is a thin-walled elastic second glove worn or to be worn over or under the first glove with the xerogel layer sandwiched between the elastomer layer of the first glove and the second glove.

In the two-piece assemblies of the invention, it is highly preferred that the two articles be a close snug fit together to cover or enclose the xerogel layer.

In the articles of the invention, the xerogel layer normally contacts the elastomer layer(s), and may be bonded thereto, but the invention also includes articles in which there are one or more other layers between the elastomer layer(s) and the xerogel layer. Where a second article is used comprising an elastomeric layer, this can be in direct contact with the xerogel or spaced therefrom by one or more other layers.

In the articles of the invention, the elastomer layers can be of the same or different materials. We prefer to use natural rubber latex layers, but other materials such as synthetic rubbers and other elastomers, eg. polyurethanes, can be

used. Normally, the articles of the invention will be made by dipping a former into solutions or dispersions of the materials to be coated thereon.

The xerogels used in the present invention must be capable of imbibing fluid upon exposure to water or physiological fluids in the event of rupture of the glove. We prefer to use synthetic polymers, or semi-synthetic polymers, eg. modified naturally occurring materials. Examples of preferred xerogels can include electrically neutral polymers or copolymers formed from monomers such as 2-hydroxyethyl methacrylate or similar hydroxy esters of methacrylic or acrylic acid, N-vinyl pyrrolidone, acrylamide, methacrylamide, N-isopropyl acrylamide or similar N-alkyl substituted derivatives of acrylamide or methacrylamide. Alternatively, the xerogels may be formed from acrylic polymers or copolymers containing charged ionic groups as a result of using salts of monomers such as acrylic acid, methacrylic acid, itaconic acid, vinyl sulphonic acid or acrylamido propane sulphonic acid in which case the xerogel polymer chains will be negatively charged. If quaternary ammonium salts of monomers such as N,N-dimethyl amino ethyl methacrylate or N-vinyl pyridine are used to form the xerogel, then the polymer chains will carry a positive charge. The xerogels to be used need not be restricted to acrylic polymers obtained by conventional free radical polymerisation but can also be based upon polymers or copolymers such as polyvinyl alcohol, polyethylene oxide or segmented polyurethanes having soft segments containing polyethylene glycol. In addition, semi-synthetic carbohydrate polymers such as hydroxyethyl cellulose, hydroxy propyl cellulose or salts of carboxymethyl cellulose and alginic acid may be used.

This list is by no means exhaustive and the polymer or copolymer of choice will depend upon the device to be constructed and the active ingredient to be used within the xerogel layer.

The xerogels may be thermoplastic or thermoset. However, in the case of cross-linked xerogels, the cross-linking must not be so great that the polymer loses its ability to imbibe or absorb fluid. The absorption of fluid by the

xerogel on rupture of the article is important in a number of respects. For example, as the xerogel contacts physiological (or other) fluid it will swell and, in so doing, will serve at least partly to seal up any rupture in the article and so confine the damage. Further, the biocide (or other active material) in the xerogel can be activated by contact with the fluid and will then act in the vicinity of the rupture to contact infectious microbes and the like. Further, the biocide can spread through and into the physiological fluid in the vicinity of the rupture to provide a zone of treatment.

The protective agent in the xerogel layer in the articles of the invention can vary widely and may be, for example, a biocide, a virucide, a bactericide, or a spermicide. Other active agents can also be used. The agents can be used singly or in any mixture of two or more thereof.

The amount of protective agent present in the xerogel will most preferably be sufficient to provide the desired effect when released upon rupture of the article. The actual amount used will depend on the material and the effect required but can be determined by routine experiment in any particular case. In general, we prefer that the xerogel layer contains, by weight, from 0.1% to 80% protective agent. In the case of biocides, for example, we prefer to use from 1% to 80%, and preferably from 2% to 75% by weight of the xerogel layer.

In many cases, it is useful to the user of an article of the invention to know that a rupture has occurred. For this purpose, a dye or other indicator can be incorporated in the article, for example, so that there is a colour change or release when rupture occurs. The dye can be in the xerogel layer, for example. Some biocides are themselves dyes and, in such cases, can provide a visible indication of rupture. Another form of indication is to rely on detection of the swelling of the xerogel layer upon contact with fluid.

The invention is of particular utility for condoms and for medical and surgical gloves, but can also be used in diaphragms, speculum sheaths, endoscope tubing, catheters, shunts, colostomy bags, food storage and packaging materials.

In order to make the articles of the invention, it is necessary to provide a layer of xerogel containing biocide (or other protective agent) between the two layers of elastomer. The xerogel layer must preferably be completely sealed within the article so that it will only contact fluid when some fault, eg. rupture or holing, of the article occurs. We prefer to make the articles by the well known dipping procedures. However, some modification of these procedures may be needed in order to be sure that the xerogel is substantially water-free.

In accordance with one preferred procedure, suitable for example for making condoms or gloves, a solution (or dispersion) of the xerogel in an organic solvent (in which its swelling is nil or negligible) is used. The solution will also contain the protective agent dissolved or suspended therein. Once a layer of the solution has been applied to the elastomer layer, a second elastomer layer can be applied thereover and the solvent and any fluid phase of the second elastomer layer simultaneously removed. Thus, for example, a former may be dipped in an aqueous rubber latex to form thereon the first elastomer layer and, after drying, the former can be dipped in (or sprayed or otherwise coated with) the organic solvent solution or dispersion of the xerogel and active agent. The article can then be dried and removed from the former (if it is to be used in association with a second article), or it can be coated by dipping the coated former into aqueous rubber latex again to provide the second elastomer layer. The coated former is then heated to drive off the solvent from the xerogel layer and the water from the second elastomer layer.

The second articles used in association with first articles of the invention will normally be made in the same way (so that they have the same shape) but will normally not have any xerogel coating.

In order that the invention may be more fully understood, reference is made to the accompanying drawings wherein:

Figure 1 is a cross sectional view of the material of one example of a surgeons' glove of the invention;



Figure 2 is a plan view of a surgeons' glove having an outer xerogel coating; and

Figure 3 is a plan view of a surgeons' glove for use with the glove of Figure 2.

Referring to Figure 1, the material comprises a first layer 1 of latex, one surface 2 of which forms the outer surface of the glove and a second layer 5 of latex, the outer surface 6 of which forms the inside surface of the glove. Sandwiched between the other surface 3 of the layer 1 and the other surface 7 of layer 2, is a layer 4 comprising an intimate mixture of a xerogel and an active agent eg. biocide. This layer 4 is dry and is maintained dry by the two layers 1 and 5 of latex material. If, however, either or both layers of latex are punctured or ruptured, fluid can enter the material and, upon contact with layer 4, will cause the xerogel to swell and become biologically active.

In the case of a surgeons' glove, the total thicknesses of the material (including any other layers present) will be from about 125 to 300 micrometres of which the xerogel layer will be about 25 - 60 micrometres thick. These thicknesses are given by way of illustration and not limitation.

Figure 2 shows a surgeons' glove 8 which is in the usual shaped, handed form for snug fitting on the hand. Glove 8 comprises a layer of latex rubber 9 with an inner coating 10 of a xerogel layer containing a biocide. The coating layer 10 is shown in the Figure although, since it is on the inside of the glove, it would not normally be visible.

Figure 3 shows a surgeons' glove 11 comprising a layer of latex rubber 12, which glove is identical to, or very slightly larger than, the glove 8 of Figure 2 but has no xerogel layer.

In use, glove 11 is first donned and then glove 8 is donned over glove 11. The coating 10 is thus sandwiched between the latex rubber layer 12 of glove 11, and the latex rubber layer 9 of glove 8.

As illustrated, glove 8 is inside out to show the inner coating.

Among the preferred features of the gloves of the invention are that:

- (a) the biocidal activity is completely suppressed under normal glove use until breach of one or both of the elastomer layers occurs;
- (b) the biocidal activity commences at the moment breach occurs as fluid contacts the xerogel;
- (c) the doses of biocide within the xerogel in the region of any breach can be high enough to kill any foreign organisms very quickly; and
- (d) the wearer of the glove can have an indication both that breach has occurred and of the location of the breach.

In order that the invention may be fully understood, an embodiment thereof will now be described by way of illustration only.

In this embodiment, there is described the preparation of a layer of xerogel, containing a biocide, sandwiched between two thin films of natural rubber, the second film having been prepared separately without a xerogel/biocide layer. For this purpose, the proprietary two-part hydrogel Aquatrix II (Trade Mark of Hydromer Inc. of Branchburg, N.J., USA) was used to provide the xerogel. Chlorhexidine digluconate was used as the biocide.

Natural rubber latex was compounded for vulcanisation by the addition of suitable quantities of sulphur, an organic accelerator, and zinc oxide, according to well-known methods. The compounded latex was prevulcanised by a period of heating at 50 degrees C and was then cast on a glass plate and spread by means of a K-bar to give a thin film having a thickness of 100 micrometres after drying.

A quantity of Aquatrix II, Part A was mixed thoroughly with one tenth of its weight of biocide and one fifth of its weight of glycerol (a plasticiser for the dried xerogel film). A quantity of Aquatrix II, Part B, equal in quantity to that of Part A used, was added to the mixture, which was then immediately spread on the surface of the dried latex film in an amount sufficient to give a layer of about 50 micrometres thick when dry. Immediate application to the rubber film is

necessary because a water-insoluble hydrogel is formed rapidly on mixing Parts A and B of the Aquatrix II. The bulk of the water was removed from the hydrogel by evaporation, after which the plate was placed in an oven at 100 degrees C for 30 minutes to complete vulcanisation of the rubber and to remove any residual water, thus converting the hydrogel into a xerogel (Film 1).

A second film of prevulcanised natural rubber was prepared as described above. This film (Film 2) was not treated with the xerogel/biocide combination but was placed on top of the dried Film 1 and the two films clamped together.

The antimicrobial efficiency of the resulting xerogel/biocide sandwich was tested as follows. Into each well of a 24-well microtitre plate was placed two millilitres of nutrient broth. The combined film was held in a slightly stretched condition on top of it. A sterile suture needle contaminated with a micro-organism was passed through the thickness of the film into a well and allowed to dwell for 30 seconds before removal. When all test wells had been treated, the rubber film was removed, and the microtitre plate covered and incubated for 24 hours at 35 degrees C.

CLAIMS:

1. A thin-walled elastic article which comprises a layer of elastomer with a layer of a xerogel containing a protective agent over at least part of a surface of the elastomer layer.
2. A thin-walled elastic article which comprises two layers of elastomer with a layer of xerogel containing a protective agent sandwiched therebetween.
3. An article according to claim 1, in association with a second thin walled elastic article to be worn or otherwise used over or under the first article with the xerogel layer sandwiched between the elastomer layer and the second article.
4. A thin-walled elastic article according to claim 1 is in the form of a glove, in association with a second article which is a thin-walled elastic second glove worn or to be worn over or under the first glove with the xerogel layer sandwiched between the elastomer layer of the first glove and the second glove.
5. An article according to claim 3 or 4, wherein said second article or second glove comprises a layer of an elastomer.
6. An article according to any of claims 1 to 5, wherein at least one of said layers of elastomer comprise natural rubber latex.
7. An article according to any of claims 1 to 6, wherein the xerogel is cross-linked but still able to imbibe or absorb fluid.
8. An article according to any of claims 1 to 7, wherein the xerogel is a synthetic or semi-synthetic polymer.

9. An article according to claim 8, wherein the xerogel is an electrically neutral polymer or copolymer formed from a hydroxyester of methacrylic or acrylic acid, N-vinyl pyrrolidone, acrylamide, methacrylamide, or an N-alkyl substituted derivative of acrylamide or methacrylamide.
10. An article according to claim 8, wherein the xerogel is an acrylic polymer or copolymer containing charged ionic groups.
11. An article according to claim 10, wherein the xerogel is a polymer or copolymer of a salt of acrylic acid, methacrylic acid, itaconic acid, vinyl sulphonic acid or acrylamido propane sulphonic acid; or the xerogel is a polymer or copolymer of a quaternary ammonium salt of N,N-dimethyl amino ethyl methacrylate or N-vinyl pyridine.
12. An article according to claim 8, wherein the xerogel is polyvinyl alcohol, polyethylene oxide or a segmented polyurethane, or a semi-synthetic carbohydrate polymer.
13. An article according to any of claims 1 to 11, wherein the protective agent is a biocide, a virucide, a bactericide, or a spermicide, or any mixture of two or more thereof.
14. An article according to any of claims 1 to 13, wherein the xerogel layer contains from 0.1 to 80% by weight protective agent.
15. An article according to any of claims 1 to 14, wherein either the article or the second article or both, contain an indicator to give a visible indication of when the article or second article is ruptured.

16. A surgeons' glove substantially as herein described with reference to the accompanying drawing.

17. An article according to claim 1, 2 or 3, which is in the form of a medical or surgical glove, a diaphragm, speculum sheath, endoscope tubing, catheter, shunt, colostomy bag, food storage bag or wrapping material, or a packaging material.

18. A method of making an article as claimed in any preceding claim, which comprises forming on a layer of elastomer, a layer of xerogel containing a protective agent.

19. A method of making an article as claimed in claim 2, which comprises providing, between two layers of elastomer, a layer of xerogel containing a protective agent.

20. The use of a layer of xerogel containing a protective agent as a barrier to fluid flow and/or disease transmission through two thin layers of elastomer, by dispensing the xerogel layer between the elastomer layers.

Fig.1.

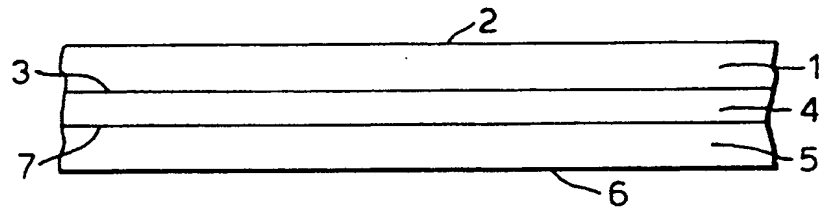


Fig.2.

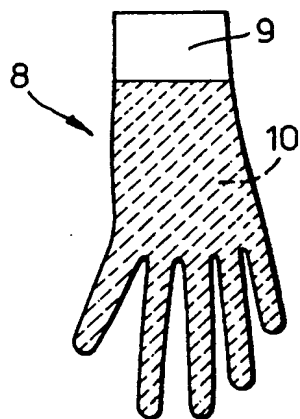
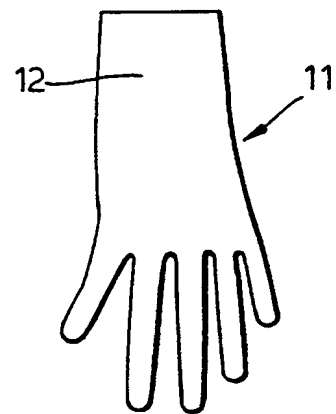


Fig.3.



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Inter national Application No  
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## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 A61L31/00 A61L29/00 A61L25/00 B32B25/04 B32B25/08

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## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61L B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 483 697 A (FUCHS INGBERT E) 16 January 1996 cited in the application see the whole document ---	1-20
X	US 5 549 924 A (SHLENKER ROBIN R T ET AL) 27 August 1996 cited in the application see the whole document ---	1, 2, 6, 8, 13-20
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X	EP 0 780 223 A (HUTCHINSON) 25 June 1997  see figures 1-4 see example 15 ---	2, 6-14, 16-20
-/-		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>WO 96 23428 A (BAXTER INT) 8 August 1996</p> <p>see page 13, line 10 - line 17</p>	<p>1, 2, 6-9, 12-14, 16-19</p>
A	<p>LESLIE LAWRENCE F ET AL: "Needle puncture resistance of surgical gloves, finger guards, and glove liners"</p> <p>J BIOMED MATER RES; JOURNAL OF BIOMEDICAL MATERIALS RESEARCH SPRING 1996, vol. 33, no. 1, April 1996, pages 41-46, XP002091405</p> <p>see the whole document</p>	<p>1-20</p>
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Information on patent family members

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